OPERATION OF A FUELCELL-HYBRID SWITCH LOCOMOTIVE IN THE LOS ANGELES BASIN

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HYBRID-FUELCELL SWITCH LOCOMOTIVE

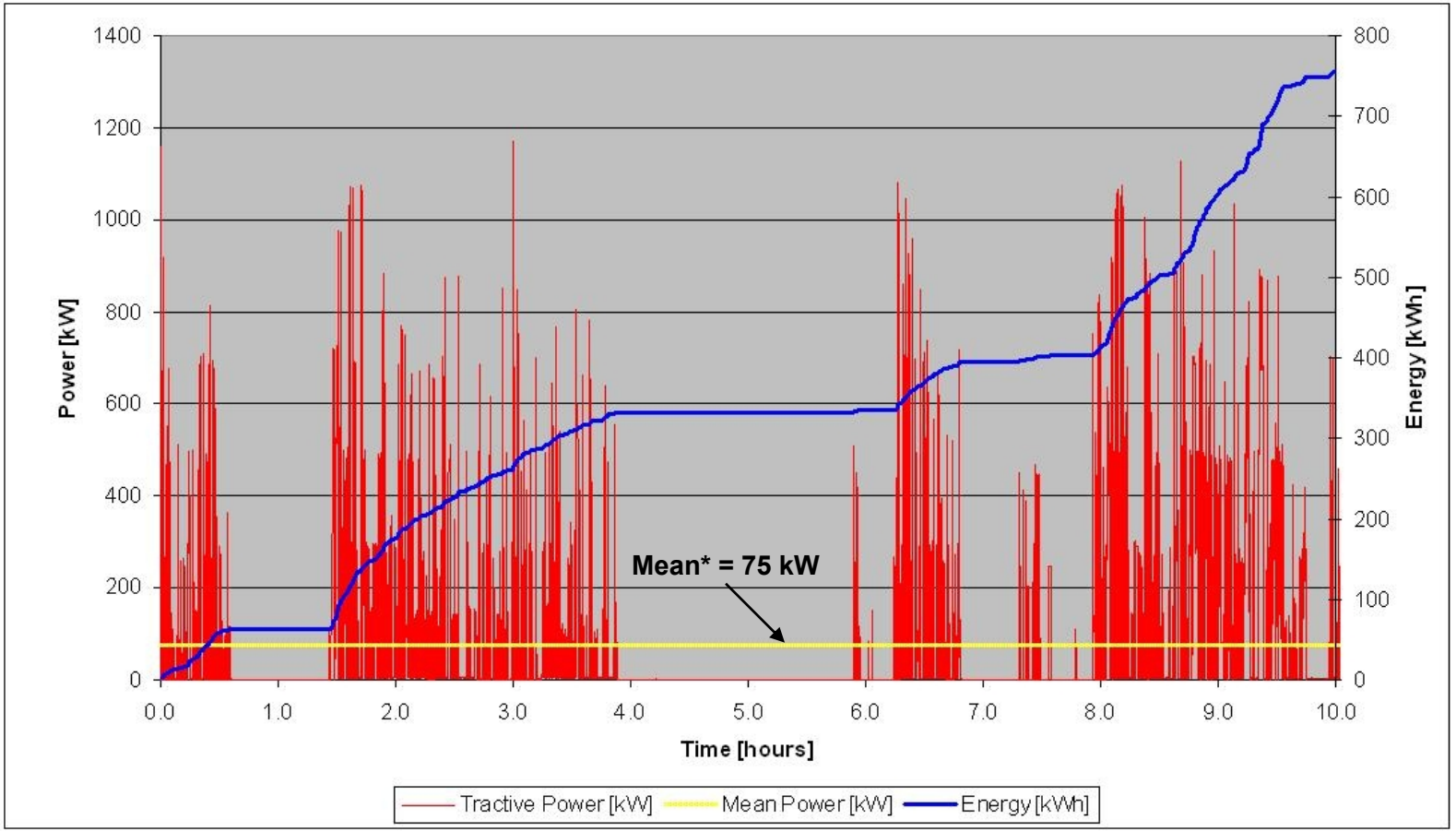
Completed locomotive at unveiling to press on 29 June 2009

WHY FUELCELL RAIL?

- **Marries best features of conventional locos (electric and diesel) but avoids their disadvantages**
  - Zero chemical and low acoustic emissions at the vehicle (like electric loco)
  - Relatively low infrastructure cost (*linear* and like diesel infrastructure)
  - Zero total CO_2 emissions if primary energy is renewable or nuclear
  - More efficient overall than diesel or electric

- **Current issues**
  - Relative high cost of fuelcells
  - Entrenched competing technologies and fuels
  - Hydrogen storage

WHY HYBRID? DUTY CYCLE OF SWITCH LOCO



*Mean power computed over 20-h interval

SWITCH LOCOMOTIVE PROJECT OBJECTIVES

An industry-government partnership has developed a prototype fuelcell-hybrid switch locomotive that will:

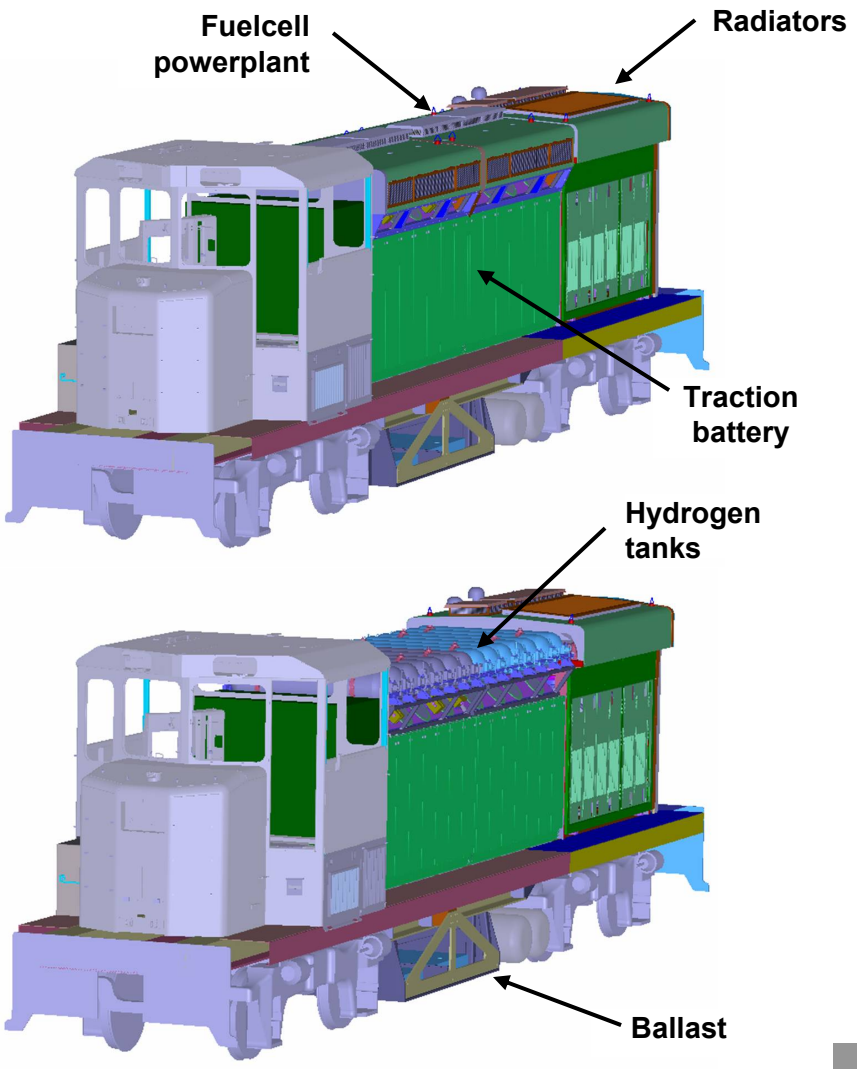
- Reduce air and noise pollution in urban rail applications, including seaports. (To be demonstrated in the Los Angeles Basin)
- Serve as a mobile backup power source (“power-to-grid”) for military bases and civilian disaster relief efforts.

FUELCELL LOCOMOTIVE UNDER CONSTRUCTION

31 July 2008, BNSF Topeka System Maintenance Terminal

CAD MODEL OF FUELCELL-HYBRID SWITCHER

- 240 kW cont. net fuelcell prime mover
- 70 kg hydrogen at 350 bar at roofline
- Traction battery allows transients above 1 MW
- 9 thousand kg extra ballast to bring to 130 tonne



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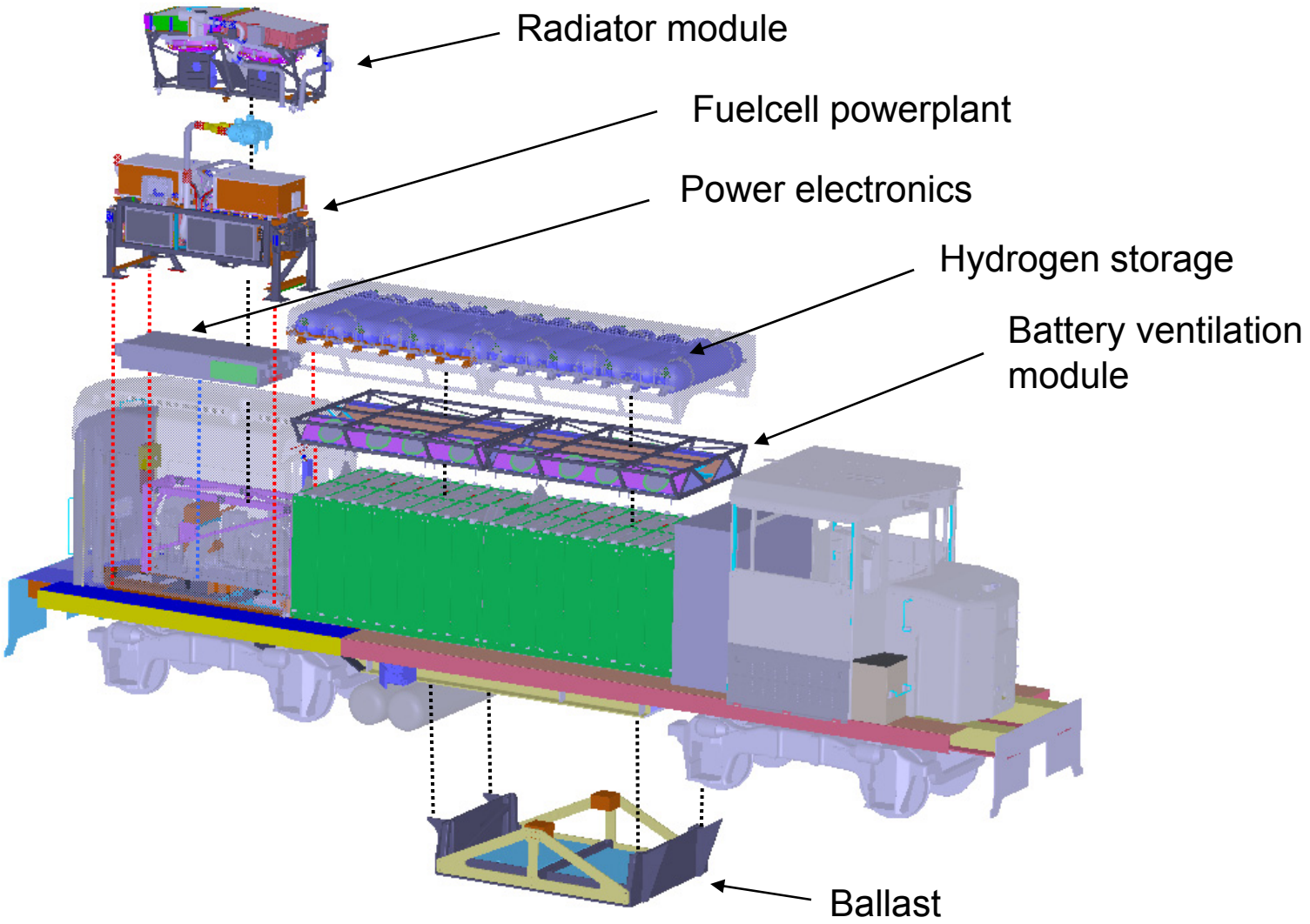
EXPANDED VIEW OF VEHICLE

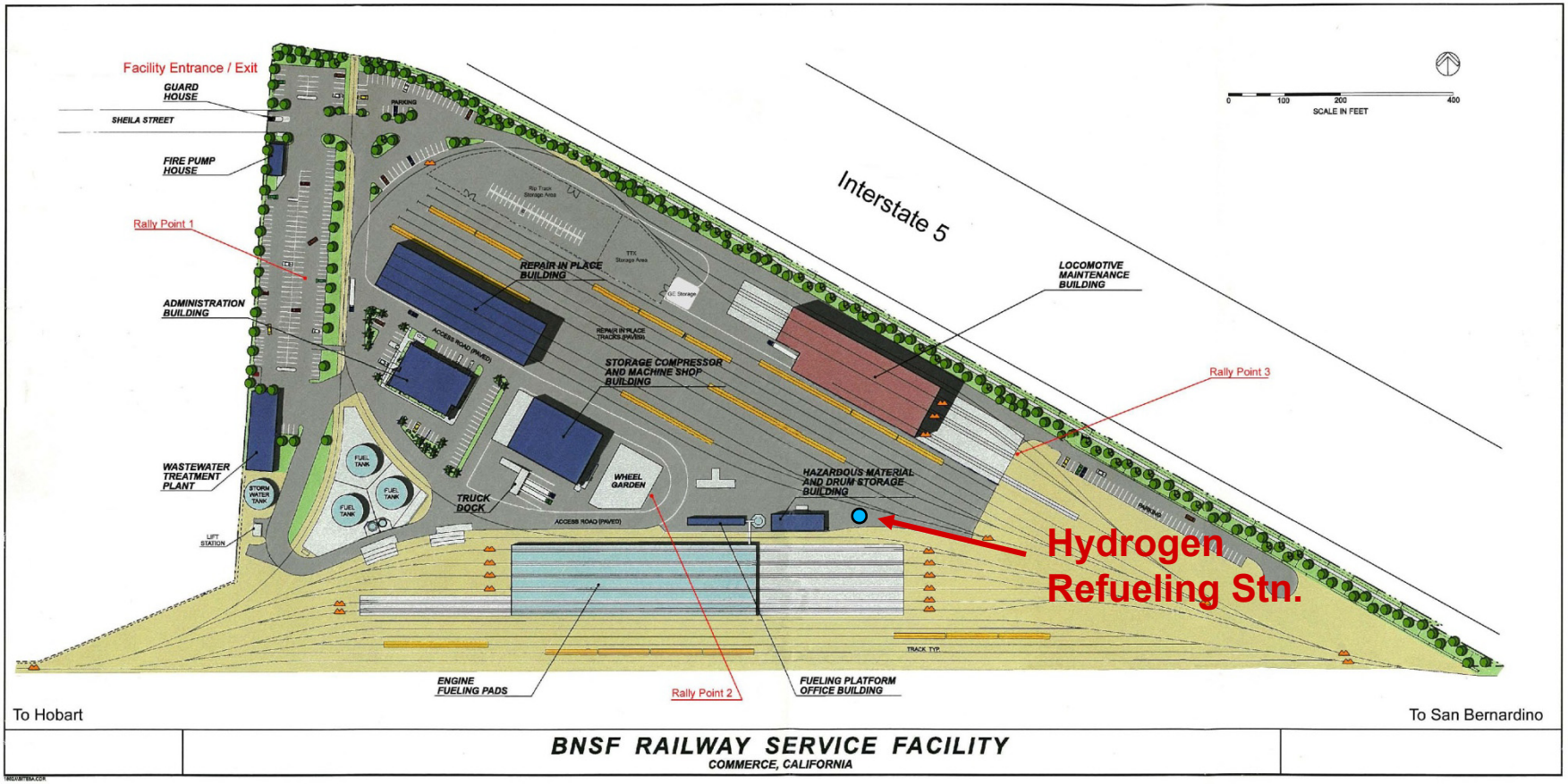


IMPACT TESTING AT DOT PROVING GROUNDS

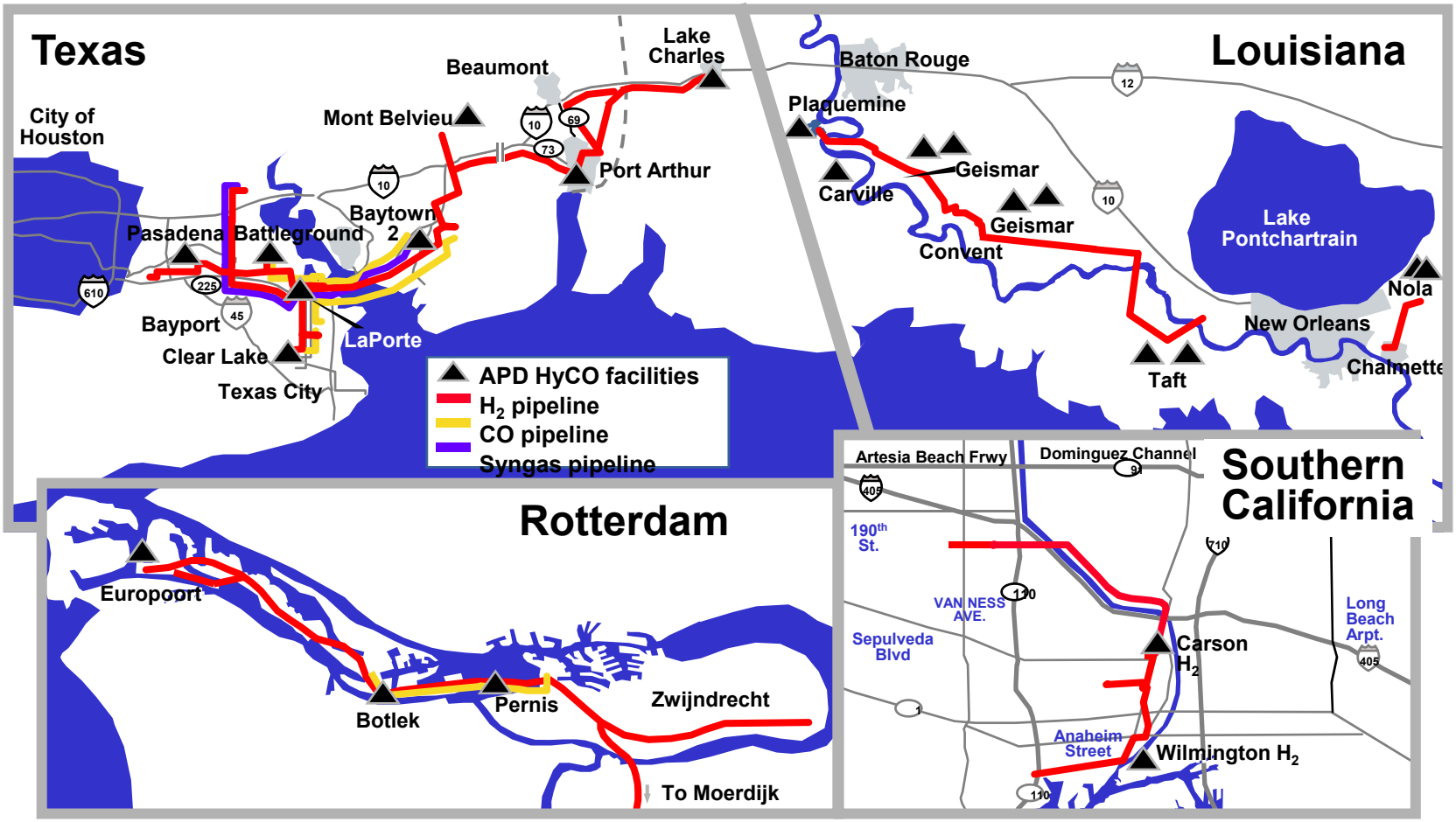
Play video of 3.8 mph impacts

HYDROGEN REFUELING STATION

DEMONSTRATION AT BNSF COMMERCE YARD



AIR PRODUCTS' HYDROGEN PIPELINES



- Serves 7 refineries in LA
- 400 thousand kg/day at 55 bar
- 26 km length; 6-10 in. diameter

RESULTS

- Locomotive is complete and has approx. 30 hours operating time
- Operating interface is identical to conventional locomotive
- Silent in cab; allows unstrained conversation beside power compartment
- Locomotive will arrive in Los Angeles in early October 2009
- With hydrogen from LA pipeline, energy cost would be lower than diesel: < $2/gal equivalent